REMARKS

Claims 1-22, 24-43 and 57-64 were pending in the Application prior to the outstanding Office Action. Applicants have presented clarifying amendments to claims 1, 13, 21, 22, 27, 34, 42, 43 and 57 as set forth above, and canceled claims 23, 61 and 63. With this Amendment, claims 1-22, 24-43, 57-60, 62 and 64 remain in the case.

Rejection of Claims 1-4, 6-15, 20, 22, 24-30, 35 and 38-40 under 35 U.S.C. §102(b) – Dane et al.

The Examiner has rejected claims 1-4, 6-15, 20, 22, 24-30, 35 and 38-40 under 35 U.S.C. §102(b) as being disclosed by Dane et al. ("Design and Operation of a 150 W Near Diffraction-Limited Laser Amplifier with SBS Wavefront Correction." IEEE Journal of Quantum Electronics, 31(1), 148-163, Jan 1995). Applicants have amended independent claims 1 and 22 to emphasize that the reflectivity of the output coupler is increased "before the relaxation oscillation pulse ends." Such action is inherent in the structure as originally stated. However, it is hoped that this clarification will aid in understanding the claim.

Reconsideration is respectfully requested.

The rejection is essentially the same as presented in the Office Action mailed on 1 December 2005. In response to that first Office Action, Applicants submitted that the Examiner had made a mistake in the analysis of the Dane et al. reference, and requested reconsideration based on that mistake.

On review of the current Office Action, Applicants believe that the following discussion of the definition of a resonator versus that of an amplifier in the laser art could be helpful. In particular, we refer to the Examiner's comment in section 14. Response to Arguments, Section 6. (Page 26) of the Office Action, reading "Light is a series of electromagnetic waves; waves inherently oscillate (See definition of "wave" from Penguin via xreferplus obtained at http://www.xreferplus.com/entry.jsp?xrefid=1442008&secid=.&hh=1; on 5/15/06), therefore the amplifier, which amplifies light, would oscillate." (Applicant has not been able to access the web page cited by the Examiner for this definition.) This just-quoted statement suggests that the Examiner may misunderstand the terminology in the claims, and is interpreting the claim language in a manner inconsistent with the common understanding in the art.

First, the term oscillate has two commonly used meanings and they are being confused here. Second, a resonator in which the oscillation pulse of claim 1 is generated is a distinctly different device than an amplifier, although they may and do have similar components.

Overview of definition of resonator vs. definition of amplifier

A discussion and subsequent differentiation of the use of the word "oscillate" as used in the present patent application and the references cited herein is critical to understanding the uniqueness of the present invention. One meaning and use of the word "oscillate" as the examiner references in the just-quoted section of the Office Action, is that the electric and magnetic fields associated with electromagnetic waves rapidly change in a sinusoidal manner from a positive value to a negative value. This oscillation occurs transverse to the direction of propagation of the wave and occurs at a rate of 10^{13} to 10^{15} cycles per second for radiation that is commonly called light, the specific rate depending on the wavelength or "color" of the light. This oscillation occurs for radio waves, for incoherent light from a flashlight, and for coherent light from a laser. In the laser community, persons of ordinary skill commonly use the word "oscillate" in an additional way with a different but universally accepted meaning.

The term "oscillate" (in the sense of oscillation within a resonator) as used in the present patent application and as commonly used by laser scientists and engineers, combines the concept of "resonate" with the requirement that a resonator device produce a resonated beam, that is a beam that interferes with itself, without the need for a similar (but typically weaker) resonated beam being externally injected. A resonator provides an optical cavity within which a beam oscillates to produce an output beam with characteristic frequencies, with no required input. In contrast an amplifier produces an output beam only when an input beam is injected. Typically the output of an amplifier is greater than its input.

Let's elaborate on the herein use of the word "resonator." (The term "oscillator" is a synonym of resonator in this context.) In this use of the word, an electromagnetic wave weakly starts from incoherent spontaneous emission out of some gain medium and has a continuous spectrum of frequencies characteristic of the gain medium. If mirrors are used to make it travel in a closed path, it returns to the gain medium where it is amplified and where it encounters more of the spontaneous emission from the gain medium. This amplified return wave interferes with the wave being continuously emitted from the gain medium. For some of the frequencies

the oscillating fields of the two waves are in phase and these frequencies constructively interfere, making these frequencies more intense. Other frequencies destructively interfere and make those frequencies weaker. This process continues with subsequent round trips and further reinforcement of the "resonating" frequencies that are characteristic of the physical length around the closed optical path. As in a sound wave "resonating" in an organ pipe at frequencies associated with the physical length of the pipe, an electromagnetic wave that "oscillates" in a laser cavity takes on characteristics associated with the physical round trip distance between the mirrors. A collection of optics with an amplifying gain medium that produces a "resonated" beam is considered a resonator.

In contrast, in an amplifier this resonating intentionally does not occur and no output is produced if no input is injected. A resonator is distinguished from an amplifier in that it produces an output without an injected input. (A resonator may have an injected input to enhance characteristics of the input, but this "injected resonator" would still produce a characteristic set of frequency outputs even if there were no injected input.)

In the laser system described in Figure 1 of Dane et al., the square box labeled "Single frequency oscillator" is the only resonator in the system. The optical ring in Dane et al. with mirrors, a gain medium, a Pockel's cell, etc. shown in detail in Figure 1 is carefully constructed not to oscillate. If one carefully follows the path of a beam propagating in this optical ring, one finds that the beam never overlaps itself in a resonant condition (remember that orthogonal polarizations can travel together and do not interfere), and can only follow a direct path into and out of the ring. As it propagates, spontaneous emission coming out of the gain medium will encounter the phase conjugator which has essentially zero reflectivity for a weak beam. Dane et al. discuss on page 150, beginning at the second column, line 5, that the SBS phase conjugator prevents "...oscillation from small reflective losses of AR coated optical surfaces in the ring...". This hardware is prevented by its design from being a resonator, even a resonator of weak "parasitic" oscillations. Any potential for oscillation to build up is intentionally prevented. The optical ring is constructed such that it is not, and cannot function as a resonator.

The Examiner refers to a definition of resonator as "Any body or system that exhibits a resonant condition at a characteristic frequency", for the Elsevier library. The system of Dane figure 1 is an amplifier and not a resonator (oscillator). Dane describes in "B. Unidirectional Uncorrected Operation, second paragraph that the "Pockels cell prevents parasitic oscillation in

the regenerative amplifier…" and in C. Operation With an SBS Conjugator , third paragraph, Dane the importance of using the SBS conjugator in the his system to prevent parasitic oscillation. The terms oscillator and resonator are synonymous to a laser engineer. The term parasitic means that this type of oscillation would be detrimental to Dane's amplifier and could damage it. Clearly Dane's amplifier is not a resonator and he works hard to make sure that it will not oscillate.

Although resonators have existed for many years, the key concepts and new hardware configurations that improve the performance of the resonator described in the present patent application are not shown in the prior art.

Discussion of the Claims

The hardware shown in Figure 1 of the Dane et al. publication, except for the box labeled "single frequency oscillator," is an amplifier. As for Claim 1, the Examiner takes the position that claimed "resonator" reads on the combination of the single frequency oscillator and the regenerative amplifier of Dane et al. The single frequency amplifier in the figure is shown simply as a labeled box. The figure shows in some detail the components of an amplifier.

The figure caption describes this as an amplifier. The paper title describes it as an amplifier. The term "regenerative" means that the beam being amplified passes through the gain medium multiple times. But without receiving an input from the single frequency resonator, this amplifier will not produce a laser output. This hardware cannot oscillate on its own.

The validity of the above statement is confirmed because the Dane et al. paper was submitted to and accepted by one of the most reputable journals on laser technology, the IEEE Journal of Quantum Electronics, and peer reviewed by top scientists in the field. Those laser physics experts did not request a change in the title "…Laser Amplifier…", and they did not propose that Figure 1 described a laser resonator.

The only component in Figure 1 that describes a resonator is the aforementioned box labeled as a single frequency oscillator.

The Examiner takes the position that the output coupler of the resonator in claim 1 reads on the Pockel's cell and polarizing beam splitter in the amplifier in Dane et al. Reconsideration is requested because this interpretation of "resonator" and of "output coupler" is not consistent with normal usage, nor with the specification as discussed above. The Pockel's cell and

polarizing beam splitter in the amplifier in Dane et al. are used in the regenerative amplifier and not in a resonator as required by the claim. In addition, the Pockel's cell and polarizing beam splitter are used only to direct the point of the output beam, and not as an output coupler of a resonator, which typically comprises a continuously operating mirror having less than 100% reflectivity. In fact, the beam in Dane et al. Figure 1 that was injected into the amplifier will come out after four round trips of the loop, independent of the polarity of the beam which is determined by the setting of the Pockel's cell. Setting the Pockel's cell voltage to rotate the polarization for the output will only send the beam along the desired output direction instead of sending it back to the single frequency oscillator where it would destroy the oscillator. The polarizing beam splitter and Pockel's cell in the amplifier of Dane et al. act as a beam steering mirror rather than an output coupler. Unlike an output coupler for a resonator, the beam steering beam splitter/Pockel's cell of Dane et al. does not direct any of the energy from the amplified pulse back through the gain medium in the amplifier, as would be needed for oscillation within a resonator.

Claim 1 includes the step of "increasing the reflectivity of the output coupler before the relaxation oscillation pulse ends." In an embodiment of the present invention of the single frequency resonator, the Pockel's cell and polarizer are combined with a voltage source to make a mirror with adjustable reflectivity that acts as an adjustable output coupler. This mirror reflectivity is chosen by setting the polarization within the resonator relative to the alignment of the polarizing beam splitter to optimize the output power and single frequency performance of the resonator. The inventors herein claim a resonator with an adjustable reflectivity output coupler that can be switched very quickly and dynamically in response to detection of a relaxation oscillation pulse. That has not been done before.

Although the amplifier does use the Pockel's cell to rotate polarization of the amplified pulse so that it is steered outside the amplifier and away from the single frequency oscillator, this action is not increasing the reflectivity of an output coupler in a resonator, as required by the claim. Thus, Applicants submit that the Examiner's reliance on the beam-steering components of the amplifier as an element of the *prima facie* case of anticipation is based on an improper interpretation of the claim.

The single frequency oscillator of Dane et al. is a resonator designed for single frequency output. Although Dane et al. only show the single frequency oscillator as a box in the figure,

they provide a discussion of its details on page 150, section D. Single Frequency Oscillator. It is useful to review this discussion to understand the important differences between it and the current invention. In Dane et al., the single frequency oscillator includes a Q-switch combined with a polarizer to form a loss element in the cavity, but not to form an output coupler. When the Q-switch is activated, the loss is made to become near zero and the cavity can react as if the Q-switch and polarizer were not present. To get useful output from the cavity in Dane et al., one has to have another mirror acting as an output coupler within the cavity with reflectivity of less than unity but sufficiently large so as to allow the oscillations to build at the optimum extraction efficiency. The single frequency oscillator of Dane et al. does not include an adjustable output coupler.

Therefore, Applicant submits that Dane et al does not anticipate claim 1.

Claims 2-4, 6-15 and 20 depend from claim 1 and are patentable for at least the same reasons, and because of the unique combinations recited.

As for Claim 6, the Examiner refers to a feature of the single frequency oscillator of Dane et al. for the first time. The detection of a relaxation oscillation pulse by detecting "leakage through the high reflectivity mirror" is similar to the technique used in the current invention. However, our claims require that an increase in the reflectivity of the output coupler be made in response to this detection. There is no similar technique described in Dane et al.

As for Claim 7, the Examiner refers to the Pockel's cell in Dane et al. that is associated with an amplifier and not with a single frequency resonator. Further, this Pockel's cell does not set a reflectivity for a mirror but rather sets the direction in which a beam is sent. In our invention, the Pockel's cell voltage is set to optimize the stability, reliability and output power of the single frequency energy buildup within a resonator cavity. We are creating an adjustable mirror and setting its optimum reflectivity which is something less than 100% and greater than 0%.

As for Claim 8, the Examiner refers to the output of the amplifier by reference to Figure 15b of Dane et al., rather than the output of the single frequency oscillator as required by the claim. In the text for Figure 15b, Dane uses, and the journal reviewers accept, the term "laser amplifier system". Dane does not refer to the amplifier as "a ring laser that generates a plurality of output pulses" because it would be absolutely recognized by Dane and the journal reviewers that the device he is describing in not capable of, and is intentionally prevented in design from,

oscillating. However, Dane does not quantify the stability of the pulse width and amplitude of the output of the single frequency oscillator. As some of the current inventors were contributors to the Dane et al. work, it is known that the current invention is an improvement to the single frequency resonator used in the work of Dane et al. As the Examiner points out, Dane does disclose that the output pulses are well defined in amplitude and pulse width, but this results because the amplifier is stable, and because the single frequency resonator that feeds the amplifier is also relatively stable.

As for Claim 9, the shape of the pulses shown in Dane's Figure 15a relied upon by the Examiner show the amplifier output, rather than the output of the single frequency oscillator.

As for Claim 20, Applicants present it now in independent form. The amplifier in Dane's Figure 1, relied upon by the Examiner, is not a resonator and clearly is not capable of producing single frequency output without having an input of single frequency from a resonator. A beam input into the regenerative amplifier of Figure 1 will indeed loop around, but it cannot resonate because at the key points where it does overlap in direction, its polarization has been flipped to the orthogonal state which prevents it from interfering with the previous pass. Dane's design of Figure 1 cannot resonate, and thus it is not a resonator with an odd number of reflectors.

Reconsideration of rejection of independent claim 22 and claims 22, 24-30, 35 and 38-40 which depend from claim 22, is requested for the reasons set forth above. As set forth above, the Examiner relies on the structure of Dane's amplifier of Figure 1, which is not a resonator and thus the components therein do not describe the design elements of the current invention.

Furthermore, we note that claim 38 recites that the "output coupler comprises a polarizing beam splitter, and including a polarization rotation element in the resonator to set an amount of light that is transmitted by the polarizing beam splitter during build up of gain." This claim literally states that the polarization rotation element sets the amount of light transmitted "during build up of gain." There is no interval corresponding to "during biuld up of gain" in the Dane amplifier. Dane in section B (pages 149-150) referred to by the Examiner, describes operating the system as an amplifier without phase conjugation. Here he discusses that the "Pockels cell prevents parasitic oscillation in the regenerative amplifier…at the polarizing beam splitter" Clearly Dane's device is an amplifier set up with care not to oscillate. The output coupler is set up as a splitter and not a mirror of adjustable reflectivity to set an amount of transmission. The physical dimensions of this regenerative amplifier, as set by the statement "a 10 mm field stop

placed at the focus of the 120 cm telescope" makes the dimensions around the amplifier ring to be in the range of 10 m, placing longitudinal cavity modes every 15 MHz apart (calculated from c/2L = 3 x 10^8/2*10). This proposed cavity is too long and the mode spacing too close for etalons to allow it to function as a single frequency oscillator. Thus it is not an oscillator and if it could be one it could not operate in single frequency.

Claim 39 recites that "the controller sets the adjustable reflectivity of the output coupler to establish a pulse width." In Dane et al. page 150 section C, third paragraph, Dane discusses "the length of the laser pulse to be amplified is limited to the transit time inside the ring minus the high voltage switching time for the Pockels cell." He further talks about "Longer pulses can be amplified…" and "the relative timing accuracy requirement between the injected pulse and the Pockels cell voltage pulse is greatly reduced." Clearly Dane is discussing a ring amplifier. Clearly the Pockels cell voltage is being used to trap and untrap an injected pulse within a ring amplifier and needs an injected input to amplifier or there is no output. Clearly the Pockels cell and beam splitter are being used as a timed beam splitter and not as a passive mirror that has a non-zero reflectivity which is then adjusted to become higher when the cavity begins to oscillate.

The pulse width is controlled according to the invention of claim 39, by the adjustable reflectivity of the output coupler. For a high reflectivity, the built up gain in the gain medium is more efficiently extracted, resulting in a shorter pulse. For a lower reflectivity, the opposite result occurs. Thus, the dynamic control of reflectivity using the Pockels' cell voltage in the described embodiment, enables pulse width control as well. No prior art single frequency oscillator is known that applies this technique. Dane is referring to a 100% switch from full transmission to full output coupling not a mirror that is partially reflecting an oscillating beam. Dane is clearly talking about an injected pulse of finite length less than the distance around the ring and making a pass of the ring without constructively interfering with itself and setting up an oscillation.

Therefore, reconsideration of the rejection of claims 1-4, 6-15, 20, 22, 24-30, 35 and 38-40, as amended, is respectfully requested.

Rejection of Claims 34, 57-59, 62 and 63 under 35 U.S.C. §102(b) - Hackel

The Examiner has rejected claims 34, 57-59, 62 and 63 under 35 U.S.C. §102(b) as being anticipated by Hackel (US 5,022,033). Applicant has amended independent claims 34 and 57, to

emphasize that the cavity loss is decreased "before the relaxation oscillation pulse ends." Such action is inherent in the structure as originally stated. However, it is hoped that this clarification will aid in understanding the claims.

In addition, claims 34 and 57 are amended to require that the ring include an odd number of reflectors. Hackel describes a system in which a low level CW beam is allowed to form in the resonant cavity. There is no detector for a relaxation oscillation pulse as required in independent claims 34 and 57. The Examiner alleges that Hackel does describe formation of a relaxation oscillation pulse. However, no citation to Hackel is provided to support the allegation. Applicants have reviewed the specification of Hackel and indeed, one of the inventors on the present application is the same Hackel, and find no mention of a relaxation oscillation pulse. Rather, the resonator in Hackel is tuned to allow a low level CW oscillation. As a CW oscillation, there is no need to detect onset of the oscillation in Hackel, and therefore no step for detecting a pulse or reacting to such a pulse as required in our claims, is described in Hackel.

In the design of Hackel, the reflectivity of all mirrors remains constant and the loss for the desired polarization is decreased upon detection of the first mode to oscillate. In the current design, when the laser is desired to produce an output pulse the circulating polarization remains constant, (in this particular design it is the polarization called P polarization) and only the reflectivity of the output mirror, formed by the polarizing beam splitter and the Pockels cell, is changed. This is important for single frequency operation because the optical path through the cavity determines what frequencies will oscillate and how stable the oscillation will be. If the circulating polarization within the cavity is changed upon switching the laser to full power then the optical path through the cavity changes and the mode that oscillates has to change. Thus the cavity is not as stable and is more prone to run at multiple frequencies. Hackel changes the polarization within the cavity to achieve seeded oscillation and thus will not be as stable and reliable single frequency as in the current invention

In addition, the cavity in Hackel has four mirrors rather than an odd number of mirrors as required by claims 34 and 57. The Hackel reference does not recognize the advantage of an odd number of reflectors for a single frequency oscillator.

An odd number of reflectors within a cavity allows misalignments to cancel as the beam propagates around the cavity. An even number causes misalignments to accumulate. An accumulation of misalignments means that the cavity length is changing with each round trip of

the beam through the cavity, and thus the resonance for the single frequency is changing and is again prone to be unstable and/or to initiate multiple frequencies. Also, accumulating misalignment of the beam means that the angle of incidence onto the etalons will deviate, potentially increasing the "walk-off".

In claims 34 and 57, the resonator includes an odd number of reflectors. This is critical for stable single frequency operation. An explanation is as follows: when a beam is directed from a first mirror (M1 in Figure 1) toward a second mirror (M2) at an angle ω with respect to a normal vector to this mirror, the beam reflects off with an equal angle ω. If the beam angle from mirror M1 increases as shown by an angle δ because the mirror misaligns slightly, then the incidence angle with respect to the normal to mirror M2 actually decreases by δ and becomes $\omega-\delta$, and the reflected angle is also $\omega-\delta$. This beam next heads toward mirror M3 and its incidence and reflected angle with respect to the normal to M3 increases by δ. Thus the beam now heads back toward mirror M1 at an angle of plus δ, but because mirror M1 had been disturbed by plus δ the beam is actually returning at an angle such that the reflected beam will match the originally disturbed beam. The angular disturbance is cancelled. This cancellation will only work for an odd number of reflectors and is critically important in maintaining single frequency because it maintains a highly controlled optical path within the oscillator, independent of disturbances. If there is an even number of reflectors, it is easy to see that the disturbance will grow with each round trip of the cavity by the oscillating beam. (Note: a typical cavity length is 1 meter and light travels at 3 ns per meter so a 25 ns pulse makes roughly 8 round trips through a cavity and thus a misalignment would accumulate 8 times in a cavity with an even number of mirrors.) This growth will change path length and support unstable modes, resulting in the loss of single frequency oscillation.

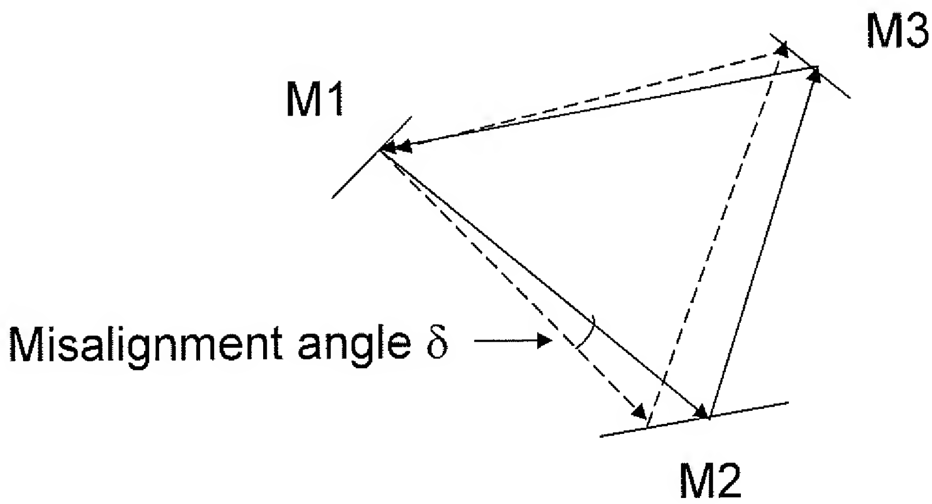

Figure 1. A misalignment of the pointing of a mirror causes a walk-off that is cancelled in a cavity with an odd number of mirrors whereas the walk-off accumulates in a cavity with an even number of mirrors

Claims 58 and 59 depend from claim 57, and claim 62 depends from claim 34, as amended, and such claims are patentable for at least the same reasons as their base claims. Claim 63 is canceled in light of the amendment of claim 34.

Furthermore, such claims recite the unique combination of etalons with a ring having an odd number of reflectors. Hackel does recognize the use of etalons, but at the time did not appreciate how sensitive the etalons would be to changing alignment within the cavity. It was recognized by the current inventors, that use of etalons in the design of Hackel created single frequency when setup but was unstable to environmental perturbations. It was recognized that environmental disturbances, such as acoustic noise and mechanical vibrations as well as temperature changes disturb the beam pointing within the cavity and cause the beam circulating within the resonator to slightly change its propagation direction and thus change the angle at which it is incident to the etalon(s).

A simple example here can illustrate the importance of canceling disturbances that result in misalignments. Take the oscillator cavity of Hackel which is about 100 centimeters round trip. Longitudinal modes will occur in this cavity spaced by integer values of N*c/n*l where N is an integer, c is the speed of light (3 x 10^10 cm/s), n is the index of refraction of the medium (here close to 1 for air) and l is the 100 centimeter distance around the cavity. (For reference to the formulas, one can refer to any reference book on laser resonators. Chapter 4 of "Introduction

to Optical electronics" by Amnon Yariv, Holt, Rinehart and Winston, 1971 is a good example). Computing this out, one gets that a resonance will occur every 300 MHz within this oscillator. Now when Hackel inserts an etalon of L = 3.0 cm length to filter out all but a single one of these frequencies, the resonance frequency of the etalon needs to match one resonance of the cavity. The resonance frequencies of the etalon are given by M*c/2*n*L where M is again an integer, n for a solid glass etalon is 1.5, and L is the etalon physical length of 3 cm. Thus the etalon has a resonance every 3300 MHz and will match up with one resonance in the cavity by appropriately tipping the etalon orientation with respect to the cavity beam to select a specific cavity resonance. (Note: the etalon is tipped also to prevent reflection feedback off of its surfaces coupling into the cavity. Assume this "reflection" tip is 1 degree or 0.017 radian and a very small additional tuning is done in addition to tune on to the cavity resonance during etalon setup. One wants to minimize the tip angle as the errors associated with walk off and shifting of the etalon resonance become more severe as the tip angle increases that is the rate of change of cosine of an angle increases as the angle moves increases away from zero or normal incidence.) Now consider any of the mirrors within the cavity and assume that they are mounted in a 2.5 cm wide holder that is adjusted with a 1 cm long screw-knob. If the screw-knob is made of steel with coefficient of thermal expansion of 6 x 10-6 per degree C, and a 0.1 degree temperature differential occurs on the screw after alignment, then the screw will change length by dl = 6 x 10-6 * 1 *0.1 = 0.6 microns, clearly a very small amount. However the mirror will tip by 0.6 microns/2.5 cm = 2.4 x 10-5 radians.

Now consider what happens to the resonance in the etalon. In the resonator of Hackel, the oscillating beam circulates the cavity every 3 ns (t = l/c = 100/3 x 10^10 = 3 ns) and thus makes roughly 10 round trips during a 30 ns long pulse. With an even number of reflectors in the cavity the pointing direction of the circulating beam will slightly increase with each trip and the angle of incidence on to the etalon will increase, or clock, by 2.4 x 10-5 radians on each round trip. Remembering that the etalon resonance is given by N*c/2*n*l where l is the physical length traveled by the light between the two faces of the etalon, and remembering that the etalon is initially tipped off normal to the beam by 0.017 radian, then physical length for resonance in the etalon will increase by 10^-6 cm on each trip and the etalon resonance will shift by 100 MHz on each trip. Remembering that the cavity modes are spaced by 300 MHz, one can see that the etalon resonance will progress from one cavity mode to the next after 3 round trips in the cavity

with an even number of reflectors but will remain stable within 100MHz in the cavity with odd number of reflectors. After 10 round trips of the main beam, the etalon resonance would have jumped 3 main cavity modes essentially allowing the output frequency to produce 3 output frequencies during the pulse duration. The use of an odd number of reflectors combined with etalons is a subtle but very important feature of a stable single frequency cavity.

Accordingly, reconsideration of the rejection of claims 34, 57-59, 62 and 63 is respectfully requested.

Rejection of Claims 5 and 31 under 35 U.S.C. §103(a) – Dane/Sokil

The Examiner has rejected claims 5 and 31 under 35 U.S.C. §103(a) as being unpatentable over Dane et al. ("Design and Operation of a 150 W Near Diffraction-Limited Laser Amplifier with SBS Wavefront Correction") in view of Sokol (US 6,384,368). Such claims are patentable for at least the same reasons as their respective base claims 1 and 22. Thus, reconsideration of the rejection of claims 5 and 31 is requested.

Rejection of Claims 16-18, 32 and 33 under 35 U.S.C. §103(a) – Dane/Ammann

The Examiner has rejected claims 16-18, 32 and 33 under 35 U.S.C. §103(a) as being unpatentable over Dane et al. ("Design and Operation of a 150 W Near Diffraction-Limited Laser Amplifier with SBS Wavefront Correction") in view of Ammann et al. (US 3,836,866).

Claims 16-18 depend from claim 1 as amended, and claims 32 and 33 depend from claim 22 as amended. Thus such claims are patentable for at least the same reasons as their respective base claims.

The Ammann et al. reference teaches triggering a Q-switch in response to the detection of a relaxation oscillation pulse. The Examiner takes the position that it would be obvious to apply the teaching of Ammann to "Dane's ring laser." Applicant believes that the Examiner is referring to the amplifier ring in Dane as discussed in detail above. In this case, no relaxation oscillation pulse will be generated in such amplifier configuration, and no detector for the onset of such a pulse would be applied to the amplifier structure for that reason. Therefore, the Examiner's combination would not work for the purpose of producing a single frequency pulse.

Moreover, Ammann discusses and confirms our argument that "laser mirror vibrations" cause instability in the build up time of the oscillation. Ammann does not discuss or address the

problem that these "mirror vibrations" cause significant instability in the single frequency operation of the laser. Ammann observes that these vibrations disturb the build up of the pulse time from shot to shot and he admits that he "circumvents the instability problem" by triggering the opening of the Q-switch on when the oscillation begins to build. Ammann circumvents the instability problem whereas the current invention is the first to devise an approach that solves the problem by negating the effect of the mirror vibrations. The reason that the mirror vibrations cause the instability in build up time as observed by Ammann is precisely associated with the pointing misalignment discussed above. Mispointing in a single frequency laser causes changes in loss and changes in optimum resonance frequency within the etalons and thus the build up time is varies as the "laser mirror vibrations" change the beam pointing within the cavity. Ammann allows the instability to occur and just synchronizes his timing to whenever the pulse begins. He does not address the associated problem of what this instability caused by "mirror vibrations" does to the single frequency operation. Our invention is the first to address this problem with a solution rather than try to circumvent it. Again one has to appreciate that the changes made in the current invention are very subtle but they very definitely address how to build a single frequency oscillator that operates in a stable manner within the pulse, and from pulse to pulse during a long sequence of pulses used in a commercial setting.

Applicants point out that the single frequency oscillator in Dane already operates in the manner taught by Ammann, by detecting a relaxation oscillation pulse.

Accordingly, reconsideration of the rejection of claims 16-18, 32 and 33 is respectfully requested.

<u>Rejection of Claims 19 and 37 under 35 U.S.C. §103(a) – Dane/Lee</u>

The Examiner has rejected claims 19 and 37 under 35 U.S.C. §103(a) as being unpatentable over Dane et al. ("Design and Operation of a 150 W Near Diffraction-Limited Laser Amplifier with SBS Wavefront Correction") in view of Lee et al. (US 4,803,694). Claim 19 depends from claim 1 as amended, and claim 37 depends from claim 22 as amended. Thus such claims are patentable for at least the same reasons as their respective base claims.

It is important to distinguish terms used commonly in laser engineering. Modes can be identified as both spatial and longitudinal. When Lee discusses TEM_{00} and Gaussian modes he is referring to spatial modes. The lowest order spatial mode, called the TEM_{00} mode is the typical

round spot with highest intensity on center and intensity tailing off at the edges that one often sees in a laser pointer. A TEM_{01} mode is comprised of 2 spots with one central lobe and a TEM_{22} is a 3 by 3 array of spots. A cavity that is running in a single spatial mode, such as TEM_{00} can absolutely be running in hundreds or even thousands of longitudinals (or frequencies) within this single spatial mode unless special means are taken to select out a single frequency. The TEM_{00} spatial mode is typically the lowest loss mode and thus laser engineers typically attempt to design a cavity to operate in the mode to create a nice round beam. However operating just in TEM_{00} single spatial mode will not in the least allow the cavity to operate in single frequency.

Accordingly, reconsideration of the rejection of claims 19 and 37 is respectfully requested.

Rejection of Claims 21 and 34 under 35 U.S.C. §103(a) – Dane/Smith

The Examiner has rejected claims 21 and 34 under 35 U.S.C. §103(a) as being unpatentable over Dane et al. ("Design and Operation of a 150 W Near Diffraction-Limited Laser Amplifier with SBS Wavefront Correction") in view of Smith et al. (US 6,282,224).

Claim 21 depends from claim 1 as amended. Thus such claim is patentable for at least the same reasons as its base claim.

Claim 34 is an independent claim, amended to require that the resonator include an odd number of reflectors, combined with an optical diode. The Examiner relies upon the ring amplifier of Dane et al. to suggest the resonator structure of claim 34. This is believed incorrect for the reasons set forth above. The Examiner relies upon Smith et al. to teach an optical diode. However, to add an optical diode to the amplifier configuration of Dane et al. would render the amplifier inoperable, by blocking the multi-pass operation of the structure. Therefore, the Examiner's combination of references would not lead a person of skill in the art to the present invention.

Accordingly, reconsideration of the rejection of claims 21 and 34 is respectfully requested.

Rejection of Claim 36 under 35 U.S.C. §103(a) – Dane/Caprara

The Examiner has rejected claim 36 under 35 U.S.C. §103(a) as being unpatentable over Dane et al. ("Design and Operation of a 150 W Near Diffraction-Limited Laser Amplifier with SBS Wavefront Correction") in view of Caprara et al. (US 6,198,756). Claim 36 depends from claim 22 as amended. Thus such claim is patentable for at least the same reasons as its base claim.

Furthermore, the mirror of Caprara is not used for adjustment of the frequency of a ring laser having an odd number of reflectors. The Caprara mirror is mounted on a piezoelectric crystal intended to adjust the length of the cavity on a scale of one or a few microns. Typically a voltage change of 200 volts changes the cavity length by 1 micron. This is used in precise laser frequency control to exactly match the resonance of the cavity to a known or reference frequency. In the present invention a flat mirror is used to make much grosser changes in the cavity length without impacting the focal positions associated with the curved mirrors. This gross adjustment allows the overall cavity length to be appropriately matched to multiples of the resonance length of the etalons to enhance the potential for single frequency operation. The curved mirrors in a ring create astigmatism and they create focal points within the cavity where for example an aperture is placed. Adjusting the curved mirrors changes the positions of the focal points and thus disrupts the entire setup of the cavity whereas adjusting the cavity length by adjusting a flat mirror maintains the positioning and beam shape and characteristics within key optical components. The piezoelectric crystal of Caprara would not be able to make the large scale adjustments made by the flat reflector mirror of the current invention.

Accordingly, reconsideration of the rejection of claim 36 is respectfully requested.

Rejection of Claim 42 under 35 U.S.C. §103(a) – Dane/Smith/Ammann

The Examiner has rejected claim 42 under 35 U.S.C. §103(a) as being unpatentable over Dane et al. ("Design and Operation of a 150 W Near Diffraction-Limited Laser Amplifier with SBS Wavefront Correction") in view of Smith et al. (US 6,282,224) and Ammann et al. (US 3,836,866. Claim 42 is an independent claim that is amended to emphasize that the Pockel's cell is used during the relaxation oscillation pulse to decrease loss in the resonator. It recites specifically the use of a polarizer and a polarizing beam splitter as an output coupler. The

combination of references relied upon by the Examiner does not yield the claimed combination as discussed in detail above.

Accordingly, reconsideration of the rejection of claim 42 is respectfully requested.

Rejection of Claim 43 under 35 U.S.C. §103(a) – Dane/Smith

The Examiner has rejected claim 43 under 35 U.S.C. §103(a) as being unpatentable over Dane et al. ("Design and Operation of a 150 W Near Diffraction-Limited Laser Amplifier with SBS Wavefront Correction") in view of Smith et al. (US 6,282,224). Claim 43 is an independent method claim that is amended to emphasize that the polarization is rotated during the relaxation oscillation pulse in combination with the use of a polarizing beam splitter for an output coupler in the resonator. The combination of references relied upon by the Examiner does not yield the claimed combination as discussed in detail above.

Accordingly, reconsideration of the rejection of claim 43 is respectfully requested.

Rejection of Claims 34, 41, 57 and 61 under 35 U.S.C. §103(a) – Dane/Smith

The Examiner has rejected claims 34, 41, 57 and 61 under 35 U.S.C. §103(a) as being unpatentable over Dane et al. ("Design and Operation of a 150 W Near Diffraction-Limited Laser Amplifier with SBS Wavefront Correction") in view of Smith et al. (US 6,282,224).

Independent claim 34 has been amended, and now recites the use of an optical diode and an odd number of mirrors in a ring configuration. The Examiner relies upon the structure of the Dane et al. amplifier to satisfy all the limitations of the claim, with the exception of the optical diode. Applicants point out that no person of skill would insert an optical diode in the regenerative amplifier structure of Dane et al. To do so would destroy the amplifier function altogether, because it is set up to provide multiple passes through the amplifier, including passes traveling in opposite directions.

Claim 41 depends from claim 34, and is patentable for at least the same reasons.

Independent claim 57 is a method claim that is amended in the manner of claim 34. It is patentable over the combination for the reasons stated above.

Claim 61 is canceled as its subject matter is incorporated into claim 57 as amended.

Accordingly, reconsideration of the rejection of claims 34, 41 and 57, as amended, is respectfully requested.

Rejection of Claims 60 and 64 under 35 U.S.C. §103(a) – Hackel/May

The Examiner has rejected claims 60 and 64 under 35 U.S.C. §103(a) as being unpatentable over Hackel (US 5,022,033) in view of May (2002/0041611).

Claims 60 and 64 depend from claims 57 and 34 respectively, and are patentable for at least the same reasons as their respective base claims.

CONCLUSION

It is respectfully submitted that this application is now in condition for allowance, and such action is requested. If the Examiner believes a telephone conference would aid the prosecution of this case in any way, please call the undersigned at (650) 712-0340.

The Commissioner is hereby authorized to charge any fee determined to be due in connection with this communication, or credit any overpayment, to our Deposit Account No. 50-0869 (MICI 1001-2).

Respectfully submitted,

Dated: 22 Aug 2006

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